



Project Summary

A Simple Method of Composition Shifting with a Distillation Column for a Heat Pump Employing a Zeotropic Refrigerant Mixture

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The report presents a simplified method of controlling heat pump capacity by shifting the composition of a zeotropic refrigerant mixture with a distillation column. Simplicity is achieved by incorporating the distillation column into the typical suction accumulator used in residential heat pumps. An experimental system employing this concept has been evaluated in the laboratory for two hydrofluorocarbon (HFC) refrigerant mixtures—HFC-32/HFC-134a (30%/70%) and HFC 32/HFC-125/HFC-134a (23%/25%/52%). For the binary mixture, the circulating refrigerant composition was shifted to HFC-32/HFC-134a (54%/46%). For the ternary mixture, the circulating refrigerant composition was shifted to HFC-32/HFC-125/HFC-134a (36%/36%/28%). Seasonal calculations have shown that these composition shifts reduce the seasonal resistance heat requirement by up to 5% compared to a conventional heat pump. Additionally, the instantaneous peak energy requirement of the dwelling has been reduced relative to a conventional heat pump by 6–9% depending on the climate region. The distillation insert should be capable of producing greater composition shifts after further optimization of the insert and improved integration with the heat pump system. For the ternary mixture, it is expected that the insert will be capable of producing a circulating refrigerant composition composed entirely of HFC-32/HFC-125.

This Project Summary was developed by EPA's National Risk Management Research Laboratory, Research Triangle

Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Overview

The heating capacity of a single-speed, air-to-air residential heat pump is directly proportional to the outdoor temperature. As the outdoor temperature falls, the system heating capacity is reduced and the compressor work input is increased, making the system less efficient. The building heat load requirement, on the other hand, increases as outdoor temperature falls. For most residential systems, as outdoor temperatures get lower, a temperature is reached (called the balance point) below which the output of the heat pump must be augmented with an auxiliary energy source to meet the heat requirement of the heated space.

The auxiliary energy is usually supplied by electric resistance heating, which has an energy efficiency much lower than a heat pump. Therefore, the heating seasonal performance factor (HSPF) of a heat pump can be increased by reducing the dependence on auxiliary electrical heating during cold weather and modulating the heat pump capacity to meet the building energy load. The increase in HSPF can be significant for colder climates, and the reduction in peak load to the electric utility can be beneficial.

To reduce the amount of auxiliary heat required, the heat pump capacity must be increased to match the building load as the outdoor temperature falls. The only commercially available heat pumps ca-

pable of matching system capacity to building load have been those which vary the volumetric capacity of the compressor. The most common ways of accomplishing this are by using two-speed compressor motors and variable-speed compressor motors with frequency inverters, both of which require considerable additional cost. Recent interest in the use of zeotropic refrigerant mixtures, prompted by the phaseout of the use of chlorofluorocarbon-based refrigerants, has provided an opportunity for an additional unique method of varying heat pump heating capacity by varying the composition of the zeotropic mixture. Specifically, by controlling mixture composition the thermodynamic properties of the refrigerant mixture can be altered to increase system capacity as the outdoor temperature drops. Using this technique, the heat pump would operate on the original refrigerant mixture until the outdoor temperature falls to the balance point and then shift the mixture composition to increase capacity.

Methods and systems for varying the capacity of a heat pump by controlling the

composition of a zeotropic mixture may be classified as either an active or passive system. An active system uses a distillation column, whereas a passive system uses a more simple accumulator. Generally, the methods that use accumulators are simple to implement but require a large refrigerant charge. Additionally, the magnitude of the composition change is limited by thermal equilibrium properties and storage space in the accumulator. Conversely, the column methods can achieve much larger composition changes at the cost of increased system complexity. Many proposed active systems have been too complex and costly to be applied in the competitive residential heat pump market.

This work presents a simplified method of controlling heat pump capacity by shifting the composition of a zeotropic refrigerant mixture with a distillation column. Simplicity is achieved by incorporating the distillation column into the typical suction accumulator used in residential heat pumps. An experimental system employ-

ing this concept has been evaluated in the laboratory for two hydrofluorocarbon (HFC) refrigerant mixtures—HFC-32/HFC-134a (30%/70%) and HFC-32/HFC-125/HFC-134a (23%/25%/52%). For the binary mixture, the circulating refrigerant composition was shifted to HFC-32/HFC-134a (54%/46%). For the ternary mixture, the circulating refrigerant composition was shifted to HFC-32/HFC-125/HFC-134a (36%/36%/28%). Seasonal calculations have shown that these composition shifts reduce the seasonal resistance heat requirement by up to 5% compared to a conventional heat pump. Additionally, the instantaneous peak energy requirement of the dwelling has been reduced relative to a conventional heat pump by 6–9% depending on the climate region. The distillation insert should be capable of producing greater composition shifts after further optimization of the insert and improved integration with the heat pump system. For the ternary mixture, it is expected that the insert will be capable of producing a circulating refrigerant composition composed entirely of HFC-32/HFC-125.

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Robert V. Hendriks is the EPA Project Officer (see below).

The complete report, entitled "A Simple Method of Composition Shifting with a Distillation Column for a Heat Pump Employing a Zeotropic Refrigerant Mixture," (Order No. PB95-255821; Cost: \$17.50, subject to change) will be available only from

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